<u>DISC DRIVE CLAMP HAVING CENTERING FEATURES</u>

by

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Related Applications

This application claims priority of United States provisional application Serial Number 60/227,618, entitled "CLAMP CENTERING FEATURE DESIGN," filed August 23, 2000.

Field of the Invention

This application relates generally to magnetic disc drives and more particularly to a disc drive clamp having centering features for improved disc pack balance.

Background of the Invention

Disc drives are data storage devices that store digital data in magnetic form on a storage medium on a rotating information storage disc. Modern disc drives include one or more rigid discs that are coated with a magnetizable medium and mounted on the hub of a spindle motor for rotation at a constant high speed. Information is stored on the discs in a plurality of concentric circular tracks typically by an array of transducers ("heads") mounted to a radial actuator for movement of the heads relative to the discs. Each of the concentric tracks is generally divided into a plurality of separately addressable data sectors. The read/write transducer, *e.g.*, a magnetoresistive read/write head, is used to transfer data between a desired track and an external environment. During a write operation, data is written onto the disc track and during a read operation the head senses the data previously written on the disc track and transfers the information to the external environment.

The heads are mounted via flexures at the ends of a plurality of actuator arms that project radially outward from the actuator body. The actuator body pivots about a shaft mounted to the disc drive housing at a position closely adjacent the outer extreme of the information storage discs. The pivot shaft is parallel with the axis of rotation of the spindle motor and the information storage discs, so that when the actuator arms are pivoted, the heads move in an arc across the surfaces of the information storage discs.

Modern disc drives include one or more information storage discs mounted on the spindle motor. Spacers are typically mounted on the spindle motor between information storage discs to

provide adequate separation between the discs for the actuator arms to movably locate the heads in relation with the disc surfaces. The information storage discs and disc spacers are collectively referred to as a disc pack. Typically, the disc pack is secured to the spindle motor hub by a downward clamping force of a disc clamp.

Disc clamps are usually stamped or milled. While milled clamps are more rigid and less prone to deflecting the abutting information storage disc surface, they are relatively expensive to produce. Consequently, the substantially less expensive leaf spring disc clamp, stamped from sheet metal, has become popular, and relatively prominent type of clamp used within the disc drive industry.

The stamped leaf spring disc clamp is typically shaped as a circular disc having a central portion and a rib portion. The central portion of the clamp has a washer-like shape and can be inclined relative to the rib portion. The central portion defines a centrally located aperture for receiving the disc clamp on the spindle hub. The rib portion of the disc clamp is peripherally located for contacting the inner diameter of the top information storage disc. A plurality of screw holes are symmetrically spaced in the central portion about the central aperture of the clamp for receiving screws used to secure the disc clamp to the spindle hub, the torqued screws exerting a downward axial force through the disc clamp and onto the top information storage disc.

A critical functional aspect of the disc clamp, stamped or milled, is how centered the disc clamp is on the disc pack assembly. Un-even or non-centered disc clamps contribute to disc pack imbalances which often result in rotational vibrations within the disc pack assembly. Rotational vibrations cause undesirable variations in the read/write signals detected by the read/write heads, and cause unwanted noise from the disc drive. Additionally, non-centered disc clamps are more prone to offsets during mechanical shock events to the disc drive.

Accordingly, there is a need in the disc drive art for an inexpensive, stamped disc clamp having a centering feature that allows the disc clamp to be centered on the disc pack during installation and use. Against this backdrop the present invention has been developed.

Summary of the Invention

In one embodiment, the invention is a disc drive spindle motor assembly which includes a cylindrical hub mounted to a spindle shaft, an information storage disc mounted on the

cylindrical hub, and a disc clamp for securing the information storage disc to the cylindrical hub. The disc clamp has a web portion and a peripheral ring, where the web portion has an inner edge fitted around the spindle hub. A series of inwardly projecting alignment tabs extend from the inner edge of the web portion to center the disc clamp and information storage disc on the spindle hub. Each inwardly extending tab has a chamfered top edge for reducing contact with the spindle hub during disc clamp installation on the spindle hub.

In another embodiment, the invention is a disc clamp for a disc drive, and includes a web portion having an inner edge, and a peripheral ring that extends below the web portion for contacting a top surface of an information storage disc. The inner edge of the web portion defines a series of equidistantly spaced inwardly extending tabs, where each tab has a chamfered top edge.

These and various other features as well as advantages which characterize the present invention will be apparent from a reading of the following detailed description and a review of the associated drawings.

Brief Description of the Drawings

FIG. **1** is a plan view of a disc drive incorporating a preferred embodiment of the present invention and illustrating the primary internal components of the disc drive.

FIG. **2** is a representative cross-sectional view of a disc pack illustrating a disc clamp in accordance with a preferred embodiment of the present invention.

FIG. **3** is an isometric view of a disc clamp in accordance with a preferred embodiment of the present invention.

FIG. **4** is a top view of a disc clamp in accordance with a preferred embodiment of the present invention.

FIG. **5** is a cross-sectional view through the disc clamp taken along line **3-3** in FIG. **4**

FIG. **6** is an expanded view of the alignment tab shown in the inset of FIG. **5**.

FIG. **7** is a representative cross section view of an alignment tab abutting a raised spindle motor hub in accordance with a preferred embodiment of the present invention.

FIG. **8** is a process flow diagram for centering a disc clamp on a motor hub assembly in conformity with one embodiment of the present invention.

Detailed Description

A disc drive **100** constructed in accordance with a preferred embodiment of the present invention is shown in FIG. **1**. The disc drive **100** includes a base plate **102** to which various components of the disc drive **100** are mounted. A top cover **104**, shown partially cut away, cooperates with the base **102** to form an internal, sealed environment for the disc drive **100** in a conventional manner. The components include a spindle motor **106** which rotates one or more information storage discs **108** at a constant high speed. Information is written to and read from tracks on the discs **108** through the use of an actuator assembly **110**, which rotates during a seek operation about a bearing shaft assembly **112** positioned adjacent the discs **108**. The actuator assembly **110** includes a plurality of actuator arms **114** which extend towards the discs **108**, with one or more flexures **116** extending from each of the actuator arms **114**. Mounted at the distal end of each of the flexures **116** is a head **118** which includes an air bearing slider (not shown) enabling the head **118** to fly in close proximity above the corresponding surface of the associated disc **108**.

During a seek operation, the track position of the heads **118** is controlled through the use of a voice coil motor (VCM) **124**, which typically includes a coil **126** attached to the actuator assembly **110**, as well as one or more permanent magnets **128** which establish a magnetic field in which the coil **126** is immersed. The controlled application of current to the coil **126** causes magnetic interaction between the permanent magnets **128** and the coil **126** so that the coil **126** moves in accordance with the well known Lorentz relationship. As the coil **126** moves, the actuator assembly **110** pivots about the bearing shaft assembly **112**, and the heads **118** are caused to move across the surfaces of the discs **108**.

The spindle motor **106** is typically de-energized when the disc drive **100** is not in use for extended periods of time. The heads **118** are moved over park zones **120** near the inner diameter of the discs **108** when the drive motor is de-energized. The heads **118** are secured over the park zones **120** through the use of an actuator latch arrangement, which prevents inadvertent rotation of the actuator assembly **110** when the heads are parked. Alternatively, the heads may be moved off of the discs **108** by loading the heads onto a peripherally located load/unload ramp (not shown).

A flex assembly **130** provides the requisite electrical connection paths for the actuator assembly **110** while allowing pivotal movement of the actuator assembly **110** during operation. The flex assembly includes a printed circuit board **132** to which head wires (not shown) are connected; the head wires being routed along the actuator arms **114** and the flexures **116** to the heads **118**. The printed circuit board **132** typically includes circuitry for controlling the write currents applied to the heads **118** during a write operation and a preamplifier for amplifying read signals generated by the heads **118** during a read operation. The flex assembly terminates at a flex bracket **134** for communication through the base plate **102** to a disc drive printed circuit board (not shown) mounted to the bottom side of the disc drive **100**.

As briefly noted above, one or more information storage discs **108** are mounted on the motor spindle hub **136** of a spindle motor **106**, as shown in FIG. **2**. A typical spindle motor **106** has a rotating motor hub **136** journaled to a non-rotating spindle shaft **138**. The spindle shaft **138** is attached to the base plate **102** and anchors the rotating motor hub **136** within the disc drive **100**. The motor spindle hub **136** rotates about the stationary spindle shaft **138** and supports the components of the disc pack **139**, *i.e.*, information storage discs **108** and disc spacers **140**. (see FIG. **2**).

The motor spindle hub **136** has a top surface **142** for receiving a disc clamp **144**, a vertically extending side-wall **146** for mounting the disc pack **148**, and an annular extending flange **150** having a loading surface **152** for receiving an information storage disc **108**. An annular shaped rim or raised location feature **147** extends upwardly from the top surface **142** of the motor spindle hub **136** to assist location and tooling for disc pack assembly.

In one embodiment, an annular disc spacer **140** is stacked on the bottom information storage disc **108**. A top information storage disc is stacked on the disc spacer **140**. Note that while two information storage discs **108** are shown in FIG. **2**, it is envisioned that more than two discs **108** and one corresponding disc spacer **140** may be used with the current invention. Furthermore, the present invention also encompasses the use of a single information storage disc **108** secured between the bottom annular flange **150** and the disc clamp **144**, or a single information storage disc **108** secured between a disc spacer **140** and the disc clamp **144**.

With continued reference to FIG. **2**, a disc clamp **144** in accordance with one embodiment of the present invention is shown sitting around the motor spindle hub **136**. A peripheral ring

154 of the disc clamp **144** exerts a downward axial force on the mounted information storage discs **108** and disc spacers **140** which are held in position between the disc clamp **144** and hub flange **150**. The disc clamp **144** exerts the downward force through a series of radially positioned screws **156** torqued into the top surface **142** of the motor spindle hub **136**.

FIG. **3** is an isometric view, and FIG. **4** is a top view, of a disc clamp **144** according to a preferred embodiment of the present invention. With reference to FIGS **3** and **4**, and continued reference to FIG. 2, the disc clamp **144** is generally circular or disc-like in shape, having a central aperture **158**, a central web portion **160** and a peripheral annular rim **154**. The central aperture **158** of the disc clamp **144** sits around the shaped location feature **147** allowing the web portion **160** of the disc clamp **144** to contact and align with the top surface **142** of the motor spindle hub **136**. The web portion **160** is flat and not substantially inclined with respect to the top surface **142** of the spindle hub **136**. The web portion **160** of the disc clamp **144** extends beyond the outer circumference of the motor spindle hub so that the peripheral annular rim **154** extends downwardly to contact the inner circumference of the top information storage disc **108** (see FIG. **2**).

Defined within the web portion **160** of the disc clamp **144** are three screw mounting holes **162** equidistantly spaced around the central aperture **158** of the disc clamp **144**. Note, however, that although three screw holes **162** are shown, other embodiments of the disc clamp **144** may have four or more screw holes as long as the holes are equidistantly spaced around the central aperture **158**. Each screw hole **162** aligns with a corresponding hole or bore on the top surface of the spindle hub. A screw **156** or other fastening structure is received in each screw mounting hole **162** and corresponding hole in the spindle hub to fasten the disc clamp to the top surface **142** of the motor hub, and consequently exert a downward clamping force onto the disc pack **159**. A series of spanner slots **164** are optionally positioned equidistantly between every two screw mounting holes **162**.

Peripheral to the web portion **160** is the annular shaped rim portion or ring **154** of the disc clamp **144**. As briefly discussed above, when positioned on the spindle hub **136**, the rim portion **154** sits beyond the outer surface of the spindle hub **136** and is axially aligned with the inner circumference **166** of the top information storage disc **108**. (see FIG. **2**)

As shown in FIG. **5**, the peripheral rim **154** of the disc clamp has a generally U-shaped cross section, where the bottom **168** of the U defines an information storage disc engagement surface **170** and the peripheral arm **172** of the U forms a series of pressure lobes **174**.

In use, the disc clamp **144** is loaded on the motor spindle hub **136**, and the information storage disc engagement surface **170** extends below the web portion **160** to form a ring or edge that uniformly engages the top information storage disc. The downward torque of the retaining screws **156** into the top surface **142** of the spindle hub **136** is uniformly translated to a downward axial force through the information storage disc engagement surface **170**.

The pressure lobes **174** of the rim portion **154** are uniformly shaped upwardly curved extensions, where the curve peak **176** of each lobe **174** is positioned laterally in-line with the center of each of the screw mounting holes **162**, and the curve minimums **178** on either side of a curve maximum **176** are positioned laterally in-line with each spanner slot **164**. (see FIG. **3**) Each pressure lobe **174** spreads and distributes the force being translated from the torqued clamp retainer screws **156**, to the information storage disc.

FIGS. **3-4** illustrates one embodiment of an inner edge **180** that defines the central aperture **158** of the disc clamp **144**. A series of protrusions or tabs **182** extend inwardly from the inner edge **180** of the web portion **160**. Each tab **182** extends an equidistance away from the inner edge **180** so as to provide a centered series of contact points for engagement of the disc clamp **144** and the rim **147** extending from the top surface of the motor spindle hub **136** (see FIGS. **2** and **7**).

As illustrated in FIGS. **6** and **7**, each alignment tab **182** has a generally cube like shape. The thickness or height of each tab may extend the entire thickness of the inner edge, or in alternative embodiments, may only extend a portion of the thickness of the inner edge **180**. In one embodiment, the tabs **182** are laterally aligned with the center of each spanner slot **164**, but note that the tabs may also be laterally aligned with the center of each screw mounting hole **162** (see also FIG. **4**).

Each alignment tab has an inwardly facing engagement face **184** for receiving the rim **147** of the motor spindle hub **136**. The engagement face **184** has a top curved portion **190** and a lower straight portion **191**. The rounded/curved **190** or chamfered portion of the engagement face **184** provides a recess or gap **192** along the top edge of the tab **182**, so that when the disc

clamp **144** is secured downwardly onto the top surface of the motor spindle hub **136**, the front engagement face **184** of the alignment tab **182** translates along the rim **147** of the motor spindle hub **136** without interfering with the rim **147**, as is discussed in more detail below.

In use, the disc clamp **144** is positioned around the spindle hub **136** allowing the web portion **160** of the disc clamp to seat against the top surface **142** of the spindle hub **136**. The lower portion **191** of the spindle shaft engagement surface **184** of the alignment tabs **182** are substantially parallel to the cylindrical wall **194** of the rim portion **147** of the motor spindle hub **136**. (see FIG. **7**). As the retainer screws **156** are torqued into the top surface **142** of the motor spindle hub **136**, the web portion **160** is pressed downwardly against the top surface **142** of the motor spindle hub **136**. The downward force is transmitted outwardly from each screw hole **162** in the disc clamp **144** to force the peripheral annular ring downward onto the top surface of the top information storage disc and therefore onto the disc pack. The action of the disc clamp **144** exerting a clamping force on the disc pack forces the inner edge **180** of the disc clamp **144** to rotate downwardly and away from the rim **147** of the motor spindle hub **136**. As the inner edge **180** of the web portion **160** is forced downward, each alignment tab **182** is rotated, to some extent, below the surface of the web portion **160** and away from the cylindrical wall **194** of the rim **147** of the motor spindle hub **136**. The curved face **190** on each tab **182** ensures that the spindle shaft engagement face **184** of the tab **182** does not contact the cylindrical wall **194** of the rim portion **147** of the motor spindle hub **136**, keeping the disc clamp **144** centered around the spindle shaft **138** and motor spindle hub **136** and avoiding any debris formation from contact between the disc clamp **144** and the motor spindle hub **136**.

An embodiment of the present invention is a method for centering a disc clamp on a motor spindle hub, as shown in FIG. **8**. In operation **800**, a disc pack **139** is assembled on the motor spindle hub **136** of the disc drive spindle motor **106**. In operation **802**, the disc clamp **144** is positioned over the rim **147** and on the top surface **142** of the motor spindle hub **136** so that the alignment tabs **182** align with the cylindrical wall of the rim **147** and center the disc clamp **144** on the disc pack. In operation **804**, the appropriate number of screws **156** are used to secure the disc clamp **144** to the motor spindle hub **136**. As the screws are torqued into the motor spindle hub, the alignment tabs along the inside edge of the disc clamp **144** move downward and away from the cylindrical wall **194** of the rim portion **147** of the motor spindle hub **136**, as the curved

face **190** of each alignment tab **182** translates along the surface of the cylindrical wall of the motor spindle hub rim.

Note, it is envisioned that embodiments of the present invention may be used with other spindle motor designs. For example, spindle motors having a spindle shaft and motor spindle hub that both rotate about a bearing sleeve. In this case, alignment tabs extending inwardly from the inner edge of the web portion would align along the cylindrical surface of the spindle shaft, but operate in the manner previously described above.

In summary, the preferred embodiment of the invention described herein is directed to a disc drive spindle motor assembly (such as **106**) having a centered disc pack (such as **159**). The disc drive spindle motor assembly has a cylindrical hub (such as **136**) mounted to a spindle shaft (such as **138**); an information storage disc (such as **108**) mounted on the cylindrical hub (such as **136**); and a disc clamp (such as **144**) having a central aperture (such as **158**), a web portion (such as **160**) and an annular ring (such as **154**). The web portion (such as **160**) of the disc clamp (such as **144**) is fitted over the spindle hub rim (such as **147**) to align a series of inwardly extending tabs (such as **182**) from an inner edge (such as **180**) of the web portion (such as **160**) with an upwardly extending rim (such as **147**) from the top surface of the motor spindle hub (such as **136**). Each tab (such as **182**) has a chamfered top edge (such as **190**) for reduced contact with the motor spindle hub during disc clamp installation on the motor spindle hub (such as **136**).

In other preferred embodiments of the present invention, the tabs are located equidistant from each other around the inner edge (such as **180**) of the web portion (such as **160**) of the disc clamp (such as **144**). In a preferred embodiment, there are three tabs.

In another preferred embodiment of the invention, the disc clamp (such as **144**) is stamped from stainless steel sheet metal.

In another preferred embodiment of the invention, the disc clamp has a series of pressure lobes (such as **174**) extending from the peripherally located ring (such as **154**) for spreading the downward force associated with disc clamp installation on the spindle hub.

In another preferred embodiment of the invention, the disc clamp has an equal number of screw holes (such as **162**) for securing the disc clamp to the cylindrical hub as tabs (such as **180**).

A further preferred embodiment of the invention described herein is directed to a disc clamp for securing an information storage disc to a cylindrical hub. The disc clamp has a web

portion (such as **160**) having an inner edge (such as **180**) that surrounds a central aperture (such as **158**), where the inner edge has a series of inwardly extending tabs (such as **180**) equidistantly spaced around the inner edge, each tab having a curved or chamfered top edge (such as **190**), and a peripheral annular ring portion (such as **168**) extending below the web portion (such as **160**) for contacting a top surface on an information storage disc (such as **108**). In some embodiments there are three tabs (such as **180**).

It will be clear that the present invention is well adapted to attain the ends and advantages mentioned as well as those inherent therein. While a presently preferred embodiment has been described for purposes of this disclosure, various changes and modifications may be made which are well within the scope of the present invention. Numerous other changes may be made which will readily suggest themselves to those skilled in the art and which are encompassed in the spirit of the invention disclosed and as defined in the appended claims.